STANDARD OPERATING PROCEDURE

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ER PROJECT

APPROVALS FOR USE

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LOS ALAMOS NATIONAL LABORATORY

Drilling Methods and Drill Site Management

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Drilling Methods and Drill Site Management

NOTE: Environmental Restoration (ER) Project personnel may produce paper copies of this procedure printed from the controlled document electronic file. However, it is their responsibility to ensure that they are trained on and utilizing the current version of this procedure. The procedure author may be contacted if text is unclear.

1.0 PURPOSE

This Standard Operating Procedure (SOP) states the responsibilities and describes the drilling methods and drilling-package implementation to meet subsurface sampling requirements for the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) at the ER Project.

2.0 TRAINING

2.1 All users of this SOP are trained by self-study and the training is documented in accordance with QP-2.2.

2.2 The **Field Team Leader** (FTL) will monitor the proper implementation of this procedure and ensure that relevant team members have completed all applicable training assignments in accordance with QP-2.2.

3.0 DEFINITIONS

3.1 *Auger flights* — Winding metal strips welded to the auger sections that carry cuttings to the surface when the auger is rotated.

3.2 *Bentonite* — A hydrous aluminum silicate in powder, granular, or pellet form that when hydrated provides a tight seal between the well casing and the borehole wall. Bentonite may also be used in a 2% to 5% mixture with Portland cement to form a grout seal that expands as the material hardens.

3.3 *Casing* — A solid piece of pipe, typically steel, stainless steel, or polyvinyl chloride (PVC) plastic, used to keep a well open in either unconsolidated materials or unstable rock and as a means to contain zone-isolation materials such as cement grout and bentonite.

3.4 *Cutter head* — An auger bit that is attached to the leading auger flight section and cuts a hole for the auger to follow. The bit may be either a coring head or a full face bit.

3.5 *Daily drilling report* — The primary record of daily drilling activity supplied by the drilling subcontractor. The FTL or the FTL's designee is responsible for confirming that reports are accurate before they are forwarded to the Subsurface Technical Team.

3.6 *Drill bit* — The cutting tool attached to the bottom of the drill string.

3.7 *Drilling Package* — A document package that includes a detailed Drilling Plan, Curation Plan, Sampling and Analysis Plan (SAP), and Geophysical Logging Plan, as necessary, to meet the sampling requirements defined in the site-specific SAP for a given Operable Unit (OU). This package is prepared by the FTL or the FTL's designee and is approved by the Subsurface Technical Team.

3.8 *Drill rods or drill pipe* — Special pipe used to transmit rotation and energy from the drill rig to the bit. The conduit which conveys circulation fluids such as air, water, or other mixtures to cool the bit and evacuate the borehole cuttings.

3.9 *Grout* — Cement or hydrated bentonite mixtures used in sealing of boreholes or wells, and for zone isolation.

3.10 *Reamer* — A type of drill bit that is used specifically for enlarging a borehole.

3.11 *Shelby tube sampler* — A thin-wall tube sampler latched into the lead auger while hollow-stem augering or pushed/driven ahead of the auger.

3.12 *Site-Specific Health and Safety Plan (SSHASP)*—A health and safety plan that is specific to a site or ER-related field activity that has been approved by an ER health and safety representative. This document contains information specific to the project including scope of work, relevant history, descriptions of hazards by activity associated with the project site(s), and techniques for exposure mitigation (e.g., personal protective equipment [PPE]) and hazard mitigation.

3.13 *Split spoon sampler* — A core barrel that can be opened to remove samples. This is a sampling method commonly used with auger drilling. The split spoon sampler can be driven into the ground or can be advanced inside hollow-stem augers.

4.0 BACKGROUND AND PRECAUTIONS

Note: This SOP is to be used in conjunction with an approved SSHASP. Also, consult the SSHASP for information on and use of all PPE.

Various drilling methods have been developed to achieve successful subsurface contact for retrieving suitable formation, gas, and water samples. These include, but are not limited to, solid-stem augering, hollow-stem augering, direct rotary drilling, reverse rotary drilling, and cable-tool drilling. Because geologic conditions range from hard rock to unconsolidated sediments, and environmental concerns are consequential, some drilling methods may be more appropriate than others. Refer to the site-specific work plan for more information on the scope of work activities for determining the method to use.

4.1 Drilling Methods

4.1.1 Hollow-Stem Augering

4.1.1.1 The hollow-stem auger is a section of seamless steel pipe. The auger flights are welded to the pipe and act as a screw conveyer to bring the cuttings to the surface. The drill rods, split-spoon core barrels, Shelby tubes and other samplers can pass through the center of the hollow-stem auger sections. The samplers may be positioned and retrieved via wireline for continuous or intermittent coring while augering.

4.1.1.2 The lowest flight in an auger drill string, or lead auger, is equipped with a cutter head. The lead auger can have either a core barrel or center plug locked onto it. The core barrel can be used to obtain the core as the auger is advanced. A center plug is sometimes used to prevent cuttings from coming up inside the auger.

4.1.1.3 Auger sections are typically 5 ft in length and have outside diameters of 4.25 to 14 in. (and an inside diameter of 2.25 to 10 in.). At the Laboratory, depths up to 350 ft have been drilled with hollow-stem augers.

4.1.1.4 Hollow-stem augers can be used as temporary casings when setting wells to prevent cave-ins of the borehole walls.

4.1.2 Direct Rotary Drilling

4.1.2.1 The air rotary drilling method works on a principle similar to the more common mud rotary method, except that air is used to lift the cuttings from the borehole. A large compressor is used to force air down the drill rods, where it passes through ports in the drill bit. As the bit cuts through the formation, cuttings are discharged to the surface and are collected in a dust-suppression system. In some harder formations, a down-the-hole hammer (DTH) may be substituted for a roller-cone bit. Compressed air is used to drive the DTH.

4.1.2.2 The Odex method is an adaptation of the air rotary method that uses a casing-driving (advancing) technique in conjunction with air rotary drilling. With the Odex system the drill bit extends outward to ream a larger hole than the casing. The casing is advanced into the hole by means of percussive energy while simultaneously drilling the hole. Because of the unconsolidated and poorly welded tuff found at Los Alamos, use of the Odex method provides the necessary casing to stabilize the borehole as it is drilled.

4.1.2.3 Air rotary coring is intermittently performed ahead of the Odex system. The core barrels have been specially designed for limited contact with the compressed air.

4.1.2.4 At the Laboratory air rotary drilling is done with the dual-wall reverse method. It involves pumping the circulating fluid (air or water) between the outer casing and the inner drill pipe. The inner drill pipe rotates the bit and the outer pipe stabilizes the borehole, minimizes cross contamination of cuttings, and minimizes inter aquifer cross contamination within the borehole. This system is generally used in boreholes that will have a depth greater than 300 ft.

4.1.3 Hand Augering

Hand augers may be used to bore shallow holes (0 to 15 ft). A typical hand auger is advanced by turning the auger into the soil until it is filled. The auger is then removed and the sample is dumped out. Motorized units for one or two operators are available and can reach depths up to 30 ft under certain conditions. Better formation samples can be obtained by the use of a thin-wall sampler in conjunction with the hand auger. Refer to ER-SOP 6.10 for detailed instruction on the use of this type of technique.

4.2 Cautions

4.2.1 Health and safety precautions involve monitoring all material that emerges from of the borehole as well as the air that exits the dust-suppression system through the use of portable field-screening instruments.

4.2.2 Due to close contact with complex drilling machinery in motion, only drilling subcontractors should operate the equipment to prevent accidents.

4.2.3 Site workers should read and understand the SSHASP and be aware of drilling operations at all times.

4.2.4 All waste generated should be handled in accordance with ER-SOP-1.06.

5.0 EQUIPMENT

A checklist of suggested equipment and supplies employed to implement this procedure is provided in Attachment A. Descriptions of some common processes and equipment, their advantages, and their limitations are given in Attachment B to help the FTL and other personnel involved with these activities assess the various drilling methods and the appropriateness of an given method to a specific ER Project site.

6.0 PROCEDURE

Operation of the drill and equipment must be in accordance with applicable industry standards, regulatory requirements, and ER Project SOPs and Quality Procedures (QPs).

Note: Deviations from SOPs are made in accordance with QP-4.2.

6.1 Preoperation Activities

6.1.1 Prepare and submit a Drilling Package to the Laboratory Subsurface Technical Team for review and approval. The Drilling Package consists of a detailed Drilling Plan, Curation Plan, SAP, and Geophysical Logging Plan.

6.1.1.1 The Drilling Plan contains detailed information on drilling requirements, methods, and objectives. Refer to ER-SOP-5.01 for detailed requirements.

6.1.1.2 The Curation Plan provides details on planned borehole material recovery and archiving as specified in the ER-SOPs in Section 12.0 of the SOP Manual.

6.1.1.3 SAPs are based on sampling requirements described in the Site-Specific Work Plans. The SAP must also describe sample handling and decontamination between samples.

6.1.1.4 If geophysical logging is needed, then a Geophysical Logging Plan must also be submitted (refer to the SAP or the site work plan).

6.1.2 Ensure that all permits and approvals found in QP-5.3 are obtained.

6.1.3 Schedule all drilling rigs and associated equipment with the Subsurface Technical Team before going out in the field. Schedule all geophysical logging and other drill-hole testing as appropriate.

6.1.4 Have all necessary work-site preparations—such as removing brush and minor obstructions, clearing access roads, and properly staking the borehole location—completed before drilling begins. Ensure that drilling areas are not traversed by utility transmission lines.

6.1.5 Prepare for the collection of potentially hazardous borehole materials. Refer to the SOPs in the SOP Manual in Section 1.0 (and specifically ER-SOP-1.06), and Section 12 for detailed information and guidance.

6.2 Operation

6.2.1 Ensure that all drilling operations are carried out as specified in the Site-Specific Drilling Package unless otherwise directed by the FTL or the FTL's designee. The termination or modification of any boring must be done in accordance with the Drilling Package or have FTL approval and be documented accordingly. All changes must be reviewed by the Subsurface Technical Team before implementation.

6.2.2 If coring is specified, use appropriate core barrels and samplers; refer to ER-SOP-6.26. The site worker is to take possession of the core and handle it in accordance with the Curation Plan and the appropriate ER-SOPs in the SOP Manual, Section 12.0 (if applicable).

6.2.3 Ensure that all samples are taken as specified in the site-specific SAP. All sampling equipment must be decontaminated as described in the SAP and in accordance with ER-SOP-1.08.

6.2.4 Ensure that the Daily Drilling Summary (Attachment C) and all other appropriate forms are completed as specified in the ER-SOPs in the SOP Manual Sections 1.0 and 12.0.

6.2.5 Monitor the collection and storage of all excess cuttings, waste materials, and decontamination solutions for proper disposal as described in ER-SOP-1.06.

6.3 Postoperation Activities

6.3.1 Ensure that all drill-site equipment is accounted for, decontaminated, and ready for shipment to the next site.

6.3.2 Make sure that all borehole locations are properly marked and recorded and that the location identification is readily visible on the location stake. The borehole identification (FIMAD designation) and survey location should be recorded on the protective casing by use of a welding rod or embedded in the concrete pad at the site.

6.3.3 Ensure that the site is restored to predrilling conditions or as specified in ER-SOP 5.01.

6.3.4 Record all final construction details or borehole abandonment information as described in ER-SOP 5.01 and ER-SOP 5.03.

7.0 REFERENCES

The following documents have been cited within this procedure.

QP-2.2, Personnel Orientation and Training

QP-4.2, Standard Operating Procedure Development

QP-4.3, Records Management

QP-5.3, Environmental Restoration Project Readiness Review

ER-SOP-1.04, Sample Control and Field Documentation

ER-SOP-1.06, Management of Environmental Restoration Project Wastes

ER-SOP-1.08, Field Decontamination of Drilling and Sampling Equipment

ER-SOP 5.01, Monitoring Well and RFI Borehole Construction

ER-SOP 5.03, Monitoring Well and RFI Borehole Abandonment

ER-SOP-6.10, Hand Auger and Thin-Wall Tube Sampler

ER-SOP-6.26, Core Barrel Sampling for Subsurface Earth Materials

ER-SOP-12.01, Field Logging, Handling, and Documentation of Borehole Materials

ER-SOP-12.02, Transportation, Receipt, and Admittance or Borehole Samples for the Sample Management Facility

ER-SOPs in the SOP Manual in Section 1.0, General Instructions

ER-SOPs in the SOP Manual in Section 12.0, Curatorial Management Activities

8.0 RECORDS

The **FTL** is responsible for submitting the following records (processed in accordance with QP-4.3) to the Records Processing Facility.

8.1 Completed Daily Drilling Summary reports (Attachment C)

8.2 Completed Daily Activity Log forms (Attachment E in ER-SOP-1.04)

8.3 Completed Records from ER-SOP-Section 1.0, General Instructions

8.4 Completed Borehole/Well Completion Information form (Attachment A in ER-SOP-5.01)

8.5 Completed Monitoring and Borehole Abandonment Information form (Attachment A in ER-SOP-5.03)

8.6 Completed Records from ER-SOP-12.01 (Attachments A–J, as necessary)

8.7 Completed Records from ER-SOP-12.02 (Attachments A–C, as necessary)

9.0 ATTACHMENTS

The document user may employ documentation formats different from those attached to/named in this procedure—as long as the substituted formats in use provide, as a minimum, the information required in the official forms developed by the procedure.

Attachment A: Equipment and Supplies Checklist for Drilling (1 page)

Attachment B: Applications and Limitations of Drilling Methods (1 page)

Attachment C: Daily Drilling Summary (1 page)

Using a token card, click here to record "self-study" training to this procedure.

If you do not possess a token card or encounter problems, contact the RRES-ECR training specialist.

Equipment and Supplies Checklist for Drilling

- ____ Hard hat
- ____ Safety glasses
- ____ Gloves
- _____ Steel-toed boots
- _____ Hearing protection
- _____ Coveralls
- _____ Appropriate clothing
- _____ Measuring tape (marked off in tenths of feet)
- _____ Large black permanent marker
- _____ Strapping tape
- _____ Hand knife
- _____ Rock hammer
- _____ Plastic sheets
- _____ Camera and film
- _____ Any applicable licenses and permits
- _____ Drill rig and accompanying equipment
- _____ Sprayer with clean, potable water (for dust control)
- _____ Hand auger, if necessary
- _____ Grout, cement, and Bentonite, as needed
- _____ Casing
- _____ Borehole material boxes
- _____ Core barrels
- _____ Sample containers
- _____ Polystyrene core cradles
- _____ Dust-suppression system, if air rotary drilling is performed
- _____ Any equipment listed or required in the SSHASP
- _____ Any additional supplies listed in associated procedures, as needed
- _____
- _____
- _____

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Application and Limitations of Drilling Methods

Drilling Method	Application or Advantages	Limitations
Hand Augering	• For very shallow boreholes • Can be used in tight quarters • Inexpensive • Rapid mobilization—little field support needed • For overburden and soft-soils sampling	• Unable to penetrate hard rock • Borehole stability problems • Labor intensive • Shallow boreholes only
Hollow-Stem Augering	• For holes less than 350 ft deep • Good core recovery • Can serve as temporary casing • Much less expensive than air rotary drilling where applicable • Good formation samples • Can be used with continuous-core sampler or with driven or push samplers	• Requires field support • May require site preparation • Sometimes a dust hazard • Can not penetrate hard formations or boulders • Hole depths to only 350 ft • May redistribute contaminates up the borehole
Air Rotary Core/Odex Casing Advanced Drilling	• Generally for boreholes greater than 300 ft deep • Casing eliminates borehole collapse and the threat of spreading contamination • Good core recovery • Rapid advancement possible • Eliminates contamination of borehole and samples by drilling fluids (other than clean, dry air) • Depths greater than 1200 ft are possible	• Samples can be pulverized • Air may modify chemical conditions • More expensive than auger drilling methods for shallow holes • Dust control required • Requires more field support and site preparation than auger drilling

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Daily Drilling Summary

Date/Time ___________________ Sheet _____ of _____

Technical Area ______ Operable Unit ___________ Site Work Plan ___________________________________

Supervisor's Signature ____

(Print name and title, then sign)

Borehole Information

Borehole ID	Drilled Interval	Shift Start Date	Shift Time	Completed By	Date	Checked By	Date

Summary of Activities: ____

Geologic Information: ____

Run Information

#	Interval	Cut	Recovered	Unrecovered	Unrecovered Interval	% Recovered	Verified By

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